TOF Fiber Data Format

Version 2.3 (13 October 2005)

The TOF fiber data format is based on the assumption that the data will be produced by HPTDC's on the TOF trays, and these data will already be preformatted by the HPTDC's. The TCPU will not manipulate the words produced by the HPTDC's but rather send them on the fiber unmodified. However, the TCPU will add additional information data words to the data stream to uniquely identify the data being sent over the fiber as well as optionally send additional debug data.

The unit of data on the DDL fiber is a 32-bit word. This matches the HPTDC data word which is also 32bit. Since the HPTDC already provides a scheme for data formatting, we will adopt this scheme in the TOF fiber data as well. The HPTDC data format defines the most significant (MSB) 4 bits of each 32-bit word as a packet identifier as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
p	p	p	p	data																											

where *pppp* is the packet identifier. The HPTDC defines 8 of the possible 16 identifiers internally, and leaves the other 8 (all identifiers with *pppp > 7)* to the user. For the TOF we will define the packet identifiers as follows:

pppp	**Packet Use**
0100	Leading edge HPTDC data
0101	Trailing edge HPTDC data
1001	Multiplicity data
1010	Header trigger data
1011	Header debug data
1100	Geographical data
1101	Header tag word
1110	TDIG Separator word
1111	reserved

Leading Edge Data

The **leading edge data** is produced by the HPTDC in "very high resolution" mode with 8 channels per HPTDC and the HPTDC defines the packet format as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	TDC				Channel			Inter.		Leading edge time																		

<p align="center">**Table 1: Leading edge HPTDC data word**</p>

where:

TDC: Programmed ID of TDC
Channel: TDC channel number (0 – 7)
Inter: Interpolation factor (2 least significant bits of time measurement)
Leading edge time: Time measurement in 100ps bins (most significant 19 bits)

Trailing Edge Data

The **trailing edge data** is produced by the HPTDC in "high resolution mode" which allows for up to 32 channels. In the TOF TDIG boards only 24 of these 32 channels are used. The HPTDC defines the packet format for these trailing edge data as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	TDC				Channel				Trailing edge time																			

Table 2: Trailing edge HPTDC data word

where:

TDC: Programmed ID of TDC
Channel: TDC channel number (0 – 31)
Trailing edge time: Time measurement in 100ps bins

Geographical Data

As shown in these two packets, the HPTDC allows the user to program a 4-bit TDC ID. In TOF we can use this TDC ID as part of the geographical information of the TDC as follows:
There are a total of 8 TDIG boards on each tray, numbered 0 to 7 with increasing eta. Each TDIG has 4 HPTDC chips. We define the ID's of the 4 TDC's of board 0 to be 0, 1, 2 (leading edge TDC's), and 3 trailing edge TDC); board 1 will have IDs 4, 5, 6, and 7; board 2 will have IDs 8 through 11; board 3 will have IDs 12 through 15. This scheme will be repeated through boards 4 through 7. In this way, each half tray will have every TDC on its TDIG board uniquely identified, and the data from each half tray will not need any additional geographical information, if these data packets are kept together on the fiber. There are a total of 120 trays in TOF, i.e. 240 half trays. We will use the "Geographical Data" packets to identify sections of "half-trays" on the fiber by pre-pending the data from each half tray with a geographical data word which is formatted as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0																							tray ID					H

Table 3: Geographical Data Word

where
- "*1100*" is the packet identifier for a geographical word,

- *"tray ID"* is a number between 1 and 120, uniquely identifying each tray according to the document "STAR Geometry" (STAR Note 229),
- *"H"* is either 0 or 1, identifying a *half tray* corresponding to 4 TDIG boards; TDIG boards 0 – 3 correspond to *H = 0,* while TDIG boards 4 – 7 correspond to *H = 1.*

Header Trigger Data

The sequence of geographical data and HPTDC data will be pre-pended on the fiber by 3 32-bit words of header data. The first word will be a trigger data word, which is formatted as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0									trigger				daq				token											

Table 4: Trigger data word (header word 1 of 3)

where:

trigger: Trigger command word from the TCD
daq: DAQ command word from the TCD
token   12-bit trigger token from the TCD

Header Debug Data

The following word is a "*Header Debug Data*" word and can be used to send additional data across the fiber to aid in debugging data errors. It is formatted as follows (the content of the data word is currently undefined):

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1																												

Table 5: Debug data word (header word 2 of 3)

Header Tag Word

The 3rd word on the fiber is a place holder for future use. For the moment, we can define this word with a tag word as its content, e.g. 0xdeadface, as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	1	1	0	1	0	1	0	1	1	0	1	1	1	1	1	1	0	1	0	1	1	0	0	1	1	1	0

Table 6: Tag data word (header word 3 of 3)

To summarize, the data sequence on the fiber with this definition would look as follows:

Word #:	Contents:
1	Header Trigger Data Word
2	Header Debug Data Word
3	Header Tag Word (0xdeadface)
4	Geographical Data (e.g. half tray 0)
5	HPTDC data word (boards 0 – 3)
…	…
5+n	HPTDC data word (boards 0 – 3)
5+n+1	Geographical Data (next half tray with data)
5+n+2	HPTDC data word (boards 4 – 7)
…	…
m	HPTDC data word (boards 4 – 7)
m+1	Geographical Data (next half tray with data)
m+2	HPTDC data word
…	…

System Test Year 5

In the running period of Run 5 at STAR we will test prototype electronics on one tray only. There will be a total of 8 TDIG and 1 TCPU associated with this one tray. We will not have a THUB in this setup, but TCPU will take the role of THUB and provide the fiber connection to DAQ.

To aid in debugging the system, we will extend the data format described above in a compatible fashion, such that the above mentioned definitions are maintained, but additional data is being sent that is not expected in the final system.

To begin with, we will use the an **error code** corresponding to different trigger error conditions in bits 20 through 27 of the **Header Trigger Data Word**. This word will therefore look as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0			Error Code							trigger				daq						token								

Table 7: Enhanced header trigger data word (Run 5)

Furthermore, we will use the "**Header Debug Data Word**" to send the L2 trigger data in case of an L2-accept. Therefore, the Header Debug will now look as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1										trigger				daq						token								

Table 8: Enhanced header debug data word (Run 5)

Each TDIG will send an additional "**Separator Word**" (with packet ID = 0xe) after all of the HPTDC data has been sent. TCPU can filter these words when it assembles events,

but to aid in debugging the data path for this running period (Run 5), TCPU will send these **"Separator Words"** unmodified over the fiber to DAQ. So that each TDIG will contribute at least one **"Separator Word"** to the data stream, even if no HPTDC data was available.

Each **"Separator Word"** contains additional information: bits 0 – 7 contain a "trigger counter" that each TDIG increments on receipt of a trigger. This counter can be reset with a CANbus message to synchronize all TDIG trigger counters. Bits 8 – 15 contain the number of data words read out from the HPTDC's of this TDIG. Finally, bits 24 – 27 contain the (unique) TDIG board ID determined from the rotary switch setting on TDIG. The board ID is a number between 0 and 7, which designates the TDIG board's tray position. To summarize, the **"Separator Word"** format is as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	Board ID												number of items								trigger counter							

Table 9: Separator word

The data on the fiber for Run 5 will then look as follows (the prototype tray is installed at location 93):

Word #:	Contents:
1	Header Trigger Data Word
2	Header Debug Data Word, L2 data
3	Header Tag Word (0xdeadface)
4	Geographical Data (tray 93, half tray 0)
5	HPTDC data word (Board 0)
…	…
5+n	HPTDC data word (Board 0)
5+n+1	Separator Word Board 0
5+n+2	HPTDC data word (Board 1)
…	…
m	HPTDC data word (Board 1)
m+1	Separator Word Board 1
m+2	HPTDC data word (Board 2)
…	…
o	HPTDC data word (Board 2)
o+1	Separator Word Board 2
o+2	HPTDC data word (Board 3)
…	…
p	HPTDC data word (Board 3)
p+1	Separator Word Board 3
p+2	Geographical Data (tray 93, half tray 1)
p+3	HPTDC data word (Board 4)
…	…
q	HPTDC data word (Board 4)
q+1	Separator Word Board 4
q+2	HPTDC data word (Board 5)
…	…
r	HPTDC data word (Board 5)
r+1	Separator Word Board 5
r+2	HPTDC data word (Board 6)
…	…
s	HPTDC data word (Board 6)
s+1	Separator Word Board 6
s+2	HPTDC data word (Board 7)
…	…
t	HPTDC data word (Board 7)
t+1	Separator Word Board 7

Appendix: Tray Geometry to Data Mapping

There are 32 modules in each tray numbered 1 – 32 with increasing eta. Each module has 6 pads (channels) numbered 1 – 6 with decreasing phi.

Module	Channel	Half Tray ID	Leading Edge TDC ID	Channel	Trailing Edge TDC ID	Channel
1	1	0	2	2	3	18
1	2	0	2	7	3	23
1	3	0	2	5	3	21
1	4	0	2	6	3	22
1	5	0	2	3	3	19
1	6	0	2	4	3	20
2	1	0	1	4	3	12
2	2	0	2	1	3	17
2	3	0	1	7	3	15
2	4	0	2	0	3	16
2	5	0	1	5	3	13
2	6	0	1	6	3	14
3	1	0	0	0	3	0
3	2	0	0	5	3	5
3	3	0	0	3	3	3
3	4	0	0	4	3	4
3	5	0	0	1	3	1
3	6	0	0	2	3	2
4	1	0	0	6	3	6
4	2	0	1	3	3	11
4	3	0	1	1	3	9
4	4	0	1	2	3	10
4	5	0	0	7	3	7
4	6	0	1	0	3	8
5	1	0	6	2	7	18
5	2	0	6	7	7	23
5	3	0	6	5	7	21
5	4	0	6	6	7	22
5	5	0	6	3	7	19
5	6	0	6	4	7	20
6	1	0	5	4	7	12
6	2	0	6	1	7	17
6	3	0	5	7	7	15
6	4	0	6	0	7	16
6	5	0	5	5	7	13
6	6	0	5	6	7	14
7	1	0	4	0	7	0
7	2	0	4	5	7	5
7	3	0	4	3	7	3
7	4	0	4	4	7	4
7	5	0	4	1	7	1
7	6	0	4	2	7	2

8	1	0	4	6	7	6
8	2	0	5	3	7	11
8	3	0	5	1	7	9
8	4	0	5	2	7	10
8	5	0	4	7	7	7
8	6	0	5	0	7	8
9	1	0	10	2	11	18
9	2	0	10	7	11	23
9	3	0	10	5	11	21
9	4	0	10	6	11	22
9	5	0	10	3	11	19
9	6	0	10	4	11	20
10	1	0	9	4	11	12
10	2	0	10	1	11	17
10	3	0	9	7	11	15
10	4	0	10	0	11	16
10	5	0	9	5	11	13
10	6	0	9	6	11	14
11	1	0	8	0	11	0
11	2	0	8	5	11	5
11	3	0	8	3	11	3
11	4	0	8	4	11	4
11	5	0	8	1	11	1
11	6	0	8	2	11	2
12	1	0	8	6	11	6
12	2	0	9	3	11	11
12	3	0	9	1	11	9
12	4	0	9	2	11	10
12	5	0	8	7	11	7
12	6	0	9	0	11	8
13	1	0	14	2	15	18
13	2	0	14	7	15	23
13	3	0	14	5	15	21
13	4	0	14	6	15	22
13	5	0	14	3	15	19
13	6	0	14	4	15	20
14	1	0	13	4	15	12
14	2	0	14	1	15	17
14	3	0	13	7	15	15
14	4	0	14	0	15	16
14	5	0	13	5	15	13
14	6	0	13	6	15	14
15	1	0	12	0	15	0
15	2	0	12	5	15	5
15	3	0	12	3	15	3
15	4	0	12	4	15	4
15	5	0	12	1	15	1
15	6	0	12	2	15	2

16	1	0	12	6	15	6
16	2	0	13	3	15	11
16	3	0	13	1	15	9
16	4	0	13	2	15	10
16	5	0	12	7	15	7
16	6	0	13	0	15	8
17	1	1	2	2	3	18
17	2	1	2	7	3	23
17	3	1	2	5	3	21
17	4	1	2	6	3	22
17	5	1	2	3	3	19
17	6	1	2	4	3	20
18	1	1	1	4	3	12
18	2	1	2	1	3	17
18	3	1	1	7	3	15
18	4	1	2	0	3	16
18	5	1	1	5	3	13
18	6	1	1	6	3	14
19	1	1	0	0	3	0
19	2	1	0	5	3	5
19	3	1	0	3	3	3
19	4	1	0	4	3	4
19	5	1	0	1	3	1
19	6	1	0	2	3	2
20	1	1	0	6	3	6
20	2	1	1	3	3	11
20	3	1	1	1	3	9
20	4	1	1	2	3	10
20	5	1	0	7	3	7
20	6	1	1	0	3	8
21	1	1	6	2	7	18
21	2	1	6	7	7	23
21	3	1	6	5	7	21
21	4	1	6	6	7	22
21	5	1	6	3	7	19
21	6	1	6	4	7	20
22	1	1	5	4	7	12
22	2	1	6	1	7	17
22	3	1	5	7	7	15
22	4	1	6	0	7	16
22	5	1	5	5	7	13
22	6	1	5	6	7	14
23	1	1	4	0	7	0
23	2	1	4	5	7	5
23	3	1	4	3	7	3
23	4	1	4	4	7	4
23	5	1	4	1	7	1
23	6	1	4	2	7	2

24	1	1	4	6	7	6
24	2	1	5	3	7	11
24	3	1	5	1	7	9
24	4	1	5	2	7	10
24	5	1	4	7	7	7
24	6	1	5	0	7	8
25	1	1	10	2	11	18
25	2	1	10	7	11	23
25	3	1	10	5	11	21
25	4	1	10	6	11	22
25	5	1	10	3	11	19
25	6	1	10	4	11	20
26	1	1	9	4	11	12
26	2	1	10	1	11	17
26	3	1	9	7	11	15
26	4	1	10	0	11	16
26	5	1	9	5	11	13
26	6	1	9	6	11	14
27	1	1	8	0	11	0
27	2	1	8	5	11	5
27	3	1	8	3	11	3
27	4	1	8	4	11	4
27	5	1	8	1	11	1
27	6	1	8	2	11	2
28	1	1	8	6	11	6
28	2	1	9	3	11	11
28	3	1	9	1	11	9
28	4	1	9	2	11	10
28	5	1	8	7	11	7
28	6	1	9	0	11	8
29	1	1	14	2	15	18
29	2	1	14	7	15	23
29	3	1	14	5	15	21
29	4	1	14	6	15	22
29	5	1	14	3	15	19
29	6	1	14	4	15	20
30	1	1	13	4	15	12
30	2	1	14	1	15	17
30	3	1	13	7	15	15
30	4	1	14	0	15	16
30	5	1	13	5	15	13
30	6	1	13	6	15	14
31	1	1	12	0	15	0
31	2	1	12	5	15	5
31	3	1	12	3	15	3
31	4	1	12	4	15	4
31	5	1	12	1	15	1
31	6	1	12	2	15	2

32	1	1	12	6	15	6
32	2	1	13	3	15	11
32	3	1	13	1	15	9
32	4	1	13	2	15	10
32	5	1	12	7	15	7
32	6	1	13	0	15	8